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VERIFICATION AND VALIDATION OF THE INTEGRATED MAINTENANCE INFORMATION SYSTEM (IMIS) DIAGNOSTIC MODULE

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This effort consisted of three segments: scenario development, test and analysis, and recommendations. The scenarios described conditions where pitfalls may exist in the current diagnostic system. Test and analysis focused on the procedures and results of demanding scenarios within the IMIS diagnostic module. Recommendations are provided based on adverse testing results.

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SUMMARY

This technical paper documents a study to validate and verify the Integrated Maintenance Information System (IMIS) diagnostic module. This effort, while focusing on the diagnostic module, evaluated limited aspects of the technical order authoring and presentation module. Although testing was done on the IMIS diagnostic system, the scenarios investigated are applicable to most diagnostic systems, and the results and recommendations may also have wider applicability.

This effort consisted of three segments: scenario development, test and analysis, and recommendations. The scenarios described conditions where pitfalls may exist in the current diagnostic system. Test and analysis focused on the procedures and results of demanding scenarios within the IMIS diagnostic module. Recommendations are provided based on adverse testing results.

The investigation proved that most fault isolation, rectification inefficiencies, and failures were the result of inaccurate or incomplete supporting data bases. Diagnostic efficiency was compromised as a result of intermittent faults and faults that could not be duplicated. An efficient diagnostic model should provide provisions to check data entries and to handle faults that come and go randomly or that cannot be duplicated.

The following recommendations were provided to resolve problems with diagnostic or supporting data base inefficiencies:

1. Incorporate a strategy in the diagnostic module to handle faults that are intermittent or cannot be duplicated.
2. Precisely correlate faults, symptoms, and repair actions to prevent unmodeled or useless supporting data base information.
3. Develop methods to allow more flexibility and ease in correcting human inputs during use of the system.
4. Incorporate sequencing capabilities to handle cannibalization and facilitation of other maintenance.

PREFACE

This paper documents the validation and verification of the Integrated Maintenance Information System (IMIS) diagnostic module, Version 3.3 for the Air Force Human Resources Laboratory, Combat Logistics Branch (LRC), under the terms of Contract #F33615-88-C-0004, Task Order #0004-02. The IMIS diagnostic module development is part of the overall IMIS concept that will demonstrate the capability to access and integrate maintenance information from multiple sources and present the information to technicians through a rugged, hand-held computer.

Research was performed by the Dayton regional office of Systems Exploration, Inc. (SEI). Principal investigators were Garth Cooke, Nicola Maiorana, Theodore Myers, and Johnnie Jernigan. The Air Force technical monitor for this task was Captain Dwayne Mason.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

Purpose

The purpose of this paper is to document the validation and verification of Version 3.3 of the Integrated Maintenance Information System (IMIS) diagnostic module. Results may be applicable to assess performance of other diagnostic modules. Identifying inefficiencies and errors in algorithms, theories, and supporting data bases is important in examining system capability and defining necessary enhancements for the IMIS.

Background

The objective of IMIS is to improve the capabilities of base-level aircraft maintenance organizations by providing technicians with a single, integrated information system for intermediate and organizational maintenance.

IMIS technology demonstrations will use a portable computer to interface with on-aircraft systems and ground-based computer systems to provide a single, integrated source of the information needed to perform maintenance on the flightline and in the intermediate shop level (Figure 1). The IMIS will access, integrate, and display maintenance information for the technician. It will provide the technician with direct access to several maintenance information systems and data bases including historical data collection and analysis systems, supply data bases, automated technical order systems, and automated training systems. The IMIS will display technical instructions, provide intelligent diagnostic and rectification advice, provide aircraft battle damage assessment information, analyze in-flight performance and failure data, analyze aircraft historical data, and interrogate on-aircraft built-in test capabilities. It will also provide the technician with easy, efficient methods to receive work orders, report maintenance actions, order parts from supply, and complete computer-aided training lessons. The portable computer will display all of the information the technician needs for on-equipment maintenance and diagnostics. The portable computer will make it possible to present quality information by taking advantage of the computer's ability to tailor information to a technician's level of expertise.

The diagnostic capability is a key element of IMIS. The IMIS diagnostic module was designed as a generic fault isolation and rectification tool capable of efficient operation in both single fault and multiple fault environments. The tool is model based; hence, it can operate equally well on any subsystem (not just electronic systems), and depends only on development and use of an effective system model which accurately defines fault, test, and rectification relationships.

As implemented in IMIS, the diagnostic module is very closely integrated with the technical order Authoring and Presentation System (APS). Procedures for performing tests and rectifications and task times for performing these activities are key elements contained in the technical order data base. Furthermore, all diagnostic outputs to the user interface are controlled by the presentation system. Hence, this validation and verification effort must evaluate some limited aspects of the IMIS technical order presentation module.

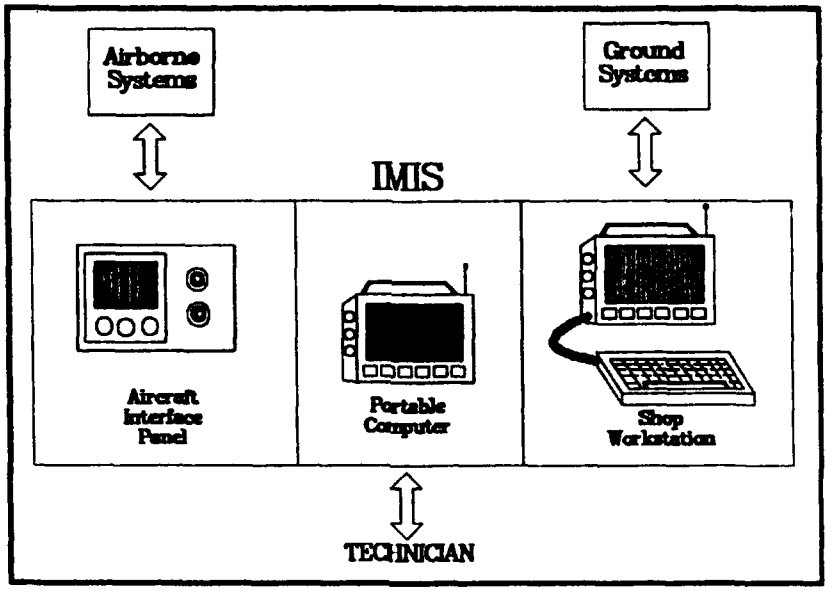

Figure 1. Integrated Maintenance Information System.

Proper performance of the diagnostic module is essential to the ultimate usefulness of IMIS; therefore, validation and verification efforts must thoroughly test the diagnostic module's capability to operate in real world conditions. The scenarios prepared for this effort and the tests performed to evaluate diagnostic capabilities against these scenarios can be applied to any diagnostic model proposed for use in an organizational maintenance environment on any kind of subsystem (electronic, mechanical, hydraulic, etc.).

Scope

The scope of this effort was to validate and verify the diagnostic efficiency and accuracy of the IMIS diagnostic module. This was accomplished through (a) defining scenarios that present demanding diagnostic problems, (b) developing and performing tests that reflect the scenarios, (c) documenting and analyzing test results, and (d) recommending solutions to shortfalls encountered.

Scenarios were developed to examine three basic issues: fault processing problems, data base inaccuracies, and user interface problems. The fault processing issues address real world conditions that place demands on current diagnostic modeling theory and implementation. Data base issues address results that could occur with incorrect data entry, incorrect data transfer, or improper data manipulation. User interface issues address the difficulties that a user may experience when correcting mistaken entries and the results of an erroneous user input on the effectiveness and the efficiency of the diagnostic sequence.

II. SCENARIOS

The following scenarios describe conditions that could tax diagnostic effectiveness but should be handled by a diagnostic system. These scenarios provided for validation and verification of diagnostic module capabilities, regulated and guided test development and documentation of results, and provided a framework for developing recommendations that stemmed from test results.

Fault Processing Issues

Can Not Duplicate (CND)

A CND problem occurs when the maintenance technician cannot duplicate a reported symptom during the fault verification or diagnostic process. An ideal diagnostic advisor would recognize a CND problem after repeated reports of the same symptom and utilize information on all rectifications performed previously to efficiently recommend an isolation and rectification process. Diagnostic advisor inaccuracies may occur in the following two situations:

1. Inaccuracies may occur when the maintenance technician does not perform a fault verification step and proceeds to fault isolate based solely upon the reported symptom. The diagnostic advisor could guide the technician through a series of "passed" tests until the implicated set contains only one fault. Upon completion of the rectification, a functional check is performed. The result of a "passed" functional check (equivalent to the fault verification step that could not be performed as a result of the CND condition) leads to the incorrect conclusion that the rectification performed fixed the problem that caused the original symptom. This sequence of events could produce high Retest OK (RTOK) rates and the true fault may not be rectified.

2. Inaccuracies also may occur when the fault verification is performed prior to diagnostics. The fault verification results will indicate no faults are found in the system and isolation of potential faults may never be initiated.

Intermittent

An intermittent fault may cause a test to fail one moment and pass the next, with no rectification action taken by the maintenance technician. This is truly a fault in the system under test, but it is one that comes and goes randomly. If a test that spans an intermittent fault should pass, this can eliminate that fault from consideration and result in an incorrect outcome. Further, if a maintenance technician performed a recommended action on a good component and the intermittent fault allowed the functional check to pass, the diagnostic system would report the fault as being fixed by the rectification. However, the true fault would still remain in the system under test.

Tests That Fix

Performing a diagnostic test can fix or alleviate a fault in some cases. For example, a bus failure might be the result of high resistance between contacts due to corrosion or tarnish. A diagnostic test which requires disconnecting and reconnecting a connector may burnish the contacts, remove the cause of the high resistance, and allow a test to pass. Upon completion of the next rectification, a functional check will be required. Given this situation, the functional check will pass provided the rectification does not insert new faults. The diagnostic module would incorrectly report alleviation of the problem due to the unnecessary rectification and would produce a RTOK at the next level of maintenance.

Retention of Test Results

A diagnostic system should retain results of all tests performed and reason properly concerning implicated and exculpated faults (potential faults that have been eliminated from consideration). However, a fault should be identified for rectification once it is isolated. Even complicated diagnostic problems require many recursive processes.

Access Groups

When ranking tests or rectifications, a diagnostic advisor should consider access groups for rectification and testing time efficiency. An access group is a collection of tests or rectifications revealed by a single maintenance activity. Once access to an area is gained, additional activities in that area can be performed at very little cost. Diagnostic efficiency may be gained when actions are performed within access groups that allow the user to gain additional information but have high access times.

"But Not" Data Entry

When entering symptoms for fault isolation, the absence of certain symptoms may exculpate faults intersecting an observed symptom's faults (Table 1).

Table 1. "But Not" Data Entry Model

		Faults				
		F1	**F2**	**F3**	**F4**	**F5**
Symptoms	**S1**	1	1	1	0	0
	S2	0	0	1	1	1

For example, as shown in Table 1, symptom S1 can be caused by faults F1, F2, or F3, and S2 can be caused by F3, F4, or F5. If the diagnostic module is designed to handle "But Not" data entry and the maintenance technician reports that S1 has been observed but not S2, then F3 can be exculpated. If S1, entered all by itself, can implicate F3, then "But Not" modeling may not be used.

Handling of Maintenance Actions

Maintenance actions are rectifications that do not involve removing and replacing (R&R) components. Rather, they require adjustment of components already in place. Diagnostic advisors should process the results (analyze and recommend action) of maintenance actions differently from those of R&R actions. For example, if a maintenance action fails to rectify certain fault(s), a parent action then needs to be performed before a functional check is performed. Hence, based on its analysis of the failed maintenance action, the diagnostic advisor should be able to recognize that the parent action must be taken.

Criticality

Aircraft functions which are required for the next planned sortie are deemed critical. This is extremely important in terms of operational requirements requiring tight schedules or quick turnarounds. The capability to distinguish between critical and noncritical functions is highly desirable in diagnostic advising systems since the presence of noncritical faults may still enable aircraft utilization. When a mode of operation is selected which implies that some sets of faults are noncritical, a diagnostic module may attempt to test or rectify critical functions early in the diagnostic process. A well-designed diagnostic aid should attempt to either implicate or exonerate the entire set of critical faults in a single preferred action. Criticality functions may be inefficient in at least three areas:

1. Immediate repair recommendations, either within or outside the critical fault set, can lose appeal because a new part might introduce a new fault.
2. Tests which span more than the critical fault set may be excluded from consideration.
3. The selection of critical tests or actions may cause diagnostic inefficiencies when compared to a diagnostic process implemented without the criticality function activated in the diagnostic system.

Data Base Issues

There are several opportunities for data element error within the automatic diagnostic tool: incorrect data entry; incorrect manipulation of data within the data base; or, in the case of newly developed components, limited availability of information on components, tests, or equipment. In view of this, a diagnostic advisor must deal effectively and efficiently with incorrect or incomplete supporting data bases.

To identify possible sources of error that may hinder the diagnostic activity and define the extent to which it may be hindered, one must (a) identify a broad array of data elements and maintenance information, (b) determine potential sources of this information, and (c) identify uses of this information within the diagnostic system. Table 2 lists data elements used within the IMIS diagnostic module and the potential sources of the information. The evaluation during this effort will focus on necessary data elements directly utilized within the IMIS diagnostic module.

Table 2. Data Elements

Data Elements	Technical Orders		
	Fault Isolation Manual	FMECA & LSAR Data	Other Sources
Symptoms	X	X	
Faults	X	X	
Rectifications	X	X	
Tests	X	X	
Mission			Aircraft Flight Manual
Test Equipment	X	X	Job Guide
Repair Level		X	RLA, LORA
MTBF		X	MODAS, FMECA, LSAR
Reference Designator	X		
National Stock No.	X		Part #/NSN Reference List
Effectivity	X		
Fault Weights			Subject Matter Experts, Tech Data
Test Times		X	Subject Matter Experts, Tech Data
Rectification Times		X	Subject Matter Experts, Tech Data
Configuration		X	Aircraft Flight Manual, Technical Order, Higher Headquarter Operating Procedures, Subject Matter Experts
Functional Groups	X		Fault Isolation Manual
Access Groups	X	X	Fault Isolation Manual

As the IMIS process matures, information will be readily available from other data bases such as Air Force Technical Order Management System (AFTOMS), Reliability and Maintainability Information System (REMIS), and Core Automated Maintenance System (CAMS.) Figure 2 illustrates proposed and developing data bases where data elements for use in the diagnostic module algorithms will be available.

The identified data elements may be categorized into two groups that show the necessity of the information gained in performing diagnostic analyses. Table 3 depicts two groups of IMIS data elements: data necessary for efficient diagnostics and data that are useful but not critical to the IMIS diagnostic module.

Table 3. Data Element Utility

Necessary	Useful
Symptoms	Test Equipment
Faults	Repair Level
Rectifications	Reference Designator
Tests	National Stock Number
Mean Time Between Failures (MTBF)[a]	Fault Weights
Test Times	System Configuration
Rectification Times	Access Groups

[a] *Component MTBF data are used to create fault* weightings if fault probability information is not available.

To evaluate the diagnostic system's ability to complete diagnostics under less than optimal data availability conditions, several scenarios have been developed that define potential problem areas. The potential problem areas include inaccurate data, incomplete data, or inaccessible maintenance information. Inaccurate, incomplete, and inaccessible maintenance information data discussions will be confined to data input, retrieval, and analysis problems within the diagnostic advisor and supporting data bases.

Inaccurate Data

The scenarios listed below will test potential areas in which the diagnostic system may be less effective due to inaccurate data.

Unseen Fault. An unseen fault occurs in the data base when a fault is implicated by a symptom but is not included in a supporting data base. What happens if the data base for a given fault contains a weight of 0%?

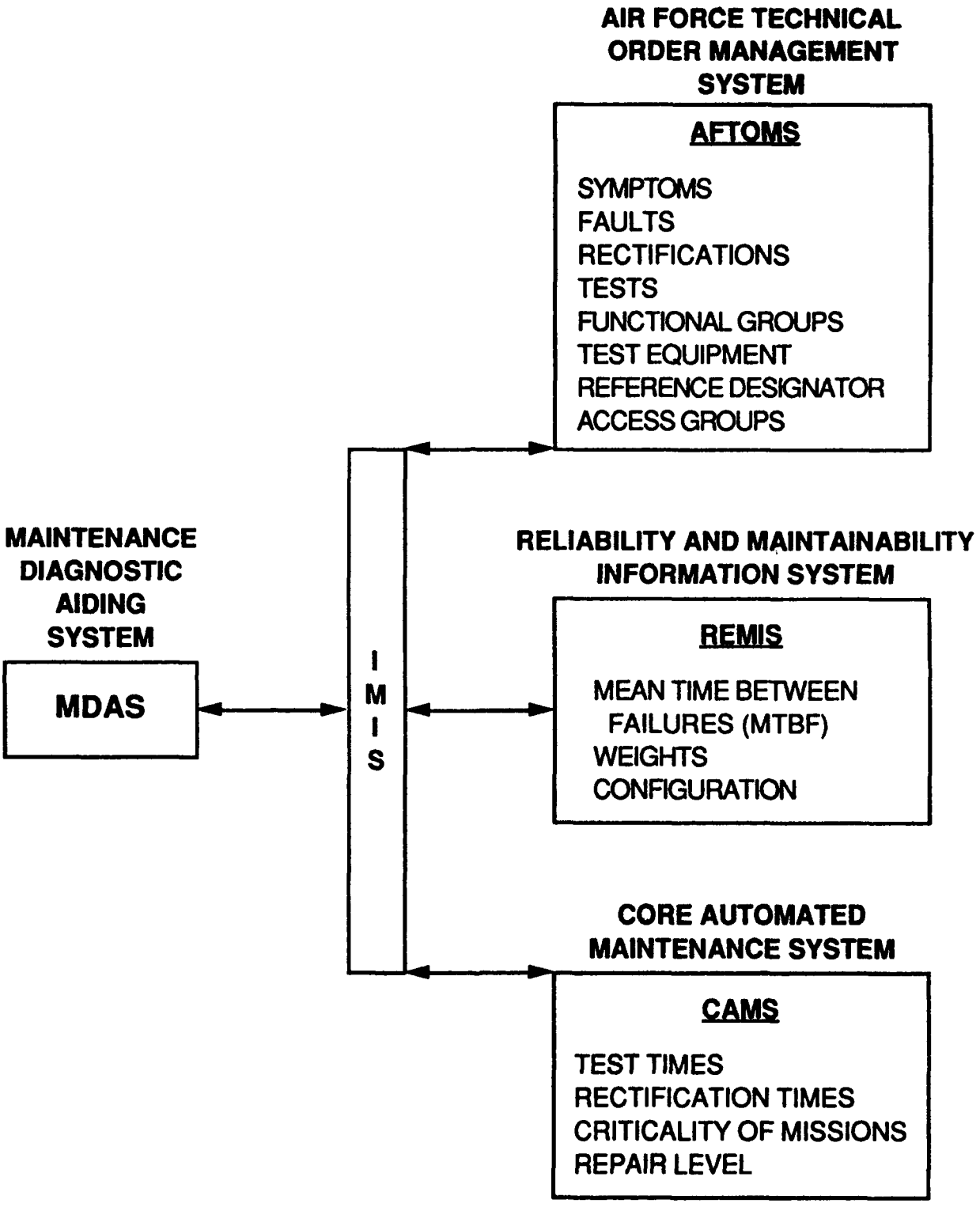

Figure 2. Data Elements Used by IMIS.

Useless Fault. A useless fault in the data base occurs when a fault is not truly implicated by a symptom but is inadvertently included in the supporting data base. To what extent are diagnostics affected?

Fault/Symptom Probability Errors. Probability errors may occur when faults are implicated by a symptom and included in the supporting data base but carry incorrect probability data. To what extent are the diagnostic system's efforts compromised by incorrect probability data?

Incomplete Data

The following scenarios describe areas in which a diagnostic system's effectiveness may be diminished because of incomplete data.

Unassigned Fault Weight/MTBF. Given neither a fault weight nor an MTBF, how does the diagnostic advisor react?

Unmodeled Symptom. An unmodeled symptom is produced by the aircraft system but not included in the data supporting the diagnostic system. The supporting data base must initially depend on data from the design process and may exclude symptoms that will appear after the equipment is fielded. How does the diagnostic system react to symptoms not included in the data base?

Unmodeled Weights/MTBFs for Fault/Symptom Relationships. Faults may be implicated by a symptom, but weight and/or MTBF data may be missing. In the event of incomplete data lists, either weight or MTBF but not both, how does the system react?

Accessibility of Maintenance Information

The following scenarios describe problems that could create difficulties for a diagnostic advisor because of an incorrect or inaccurate supporting maintenance information data base.

Unmodeled Tests and Rectifications. An observed symptom may implicate a fault for which no tests, rectifications, or maintenance actions are available for isolation or repair. If a fault is not modeled to a test, rectification, or maintenance action, what choices of action does the maintenance technician have available?

Unmodeled or Incorrect Action Times. Test and rectification times are key elements of analyses that determine the best action. When not available, their absence may pose calculation problems. Activity values in the IMIS diagnostic module are based upon information gained per unit time. Therefore, a zero or blank value for activity time, if passed to the diagnostic algorithms from the data base, may result in system failure. How does the diagnostic system react to this problem? This situation could be a result of the lack of information early in the life cycle of a weapon system.

Useless Tests and Rectifications. Inaccurate fault-to-rectification modeling may result in a rectification action that does not actually repair the fault as indicated in the data base. When

faced with such a circumstance, what alternatives are available to the diagnostic system and the maintenance technician?

Inaccurate fault-to-test modeling would result in a test that does not actually span the set of faults that are indicated in the data base. When faced with such a circumstance, what alternatives are available to the diagnostic system and the maintenance technician?

Unseen Test Faults. A test may evaluate faults not shown in the data base as being spanned by the test (faults not considered in the table relationship). Therefore, a failed test may result in the rectification of the incorrect component. Can the diagnostic system handle such a situation gracefully?

Missing Technical Order Information. Incorrect information or no information may appear when a rectification sequence is selected. In light of this, what options are available to a diagnostic system and the maintenance technician?

User Interface Issues

Six user interface scenarios have been defined to test a diagnostic system's ability to deal with potential real world problems: (a) incorrect user inputs, (b) reentry of fault/symptom information after a functional check, (c) handling of data bus outputs, (d) initialization/reinitialization of the diagnostic session, (e) return of more than one outcome from a Multiple Outcome Test (MOT), and (f) rectification and test sequencing.

Incorrect User Input

Correct user input is of major importance to the efficiency and effectiveness of diagnostic activity. The IMIS diagnostic module's user inputs are listed in Table 4, and relative impact of their effect on efficient diagnostics is shown. "Crucial" user inputs represent choices that, when performed incorrectly, may corrupt maintenance aiding ability with no hope of recovery. "Important" inputs represent user interface selections that, if made incorrectly, will lead to inefficient diagnostics. "Not important" choices do not initiate diagnostic activity within the diagnostic system.

Criticality. Diagnostic activity might be inadvertently or incorrectly initiated with criticality invoked but mission criticality is of little importance. Can adverse effects be exhibited when the actual fault is not critical?

Symptom. Incorrect user input for symptoms could take two forms, both of which might be fatal if the incorrect entry is not discovered by the maintenance technician. In the two scenarios below, can changes to the status create difficulties in diagnostic analyses? Are there any restrictions as to when these changes can be made?

1. Incorrectly marked symptom. This event occurs when a symptom is designated but is not an exhibited symptom.
2. Unmarked symptom. This event results when a symptom is exhibited by the system under test but is not designated for diagnostic analyses.

Table 4. User Input Criticality

User Inputs	Not Important	Important	Crucial
Criticality			X
Symptoms			
Initialization Input			X
Re-initialization (remove, add)			X
Test Choice		X	
Rectification Choice		X	
Test Results			X
Funct. Chk. Results			X
Exiting MDAS			X
Display Tests	X		
Display Rectifications	X		
Display Actions	X		
ETIC	X		
Look Ahead	X		

Test Results. There are two scenarios which provide insights to diagnostic advisor reactions when faced with incorrect test result entries:

1. Single incorrect entry. This situation results when a single incorrect test outcome entry is made. Does the diagnostic advisor provide the capability to back up in the event of a single incorrect entry? What results are observed when the incorrect test result is not reentered, and can diagnostics be completed with the rectification of the true fault?
2. Multiple incorrect entries. Occasionally, a new maintenance technician may forget diagnostic intricacies or lack knowledge of test outcomes. In this situation, a maintenance technician may enter incorrect test outcomes with consistency. Can the diagnostic advisor recover or identify such a situation?

Functional Check Results. Two scenarios that provide insights to diagnostic system reactions when faced with incorrect entry of functional check results are shown below. These are similar to the test result scenarios shown above, but the effects may be very different.

1. Single incorrect entry. This situation occurs when a single incorrect functional check outcome entry is made. Can the diagnostic advisor be given the capability to back up in the event of a single incorrect entry? What options are available after an incorrect entry, and can diagnostics be completed successfully?
2. Multiple incorrect entries. At times, a new maintenance technician may enter incorrect functional check outcomes consistently. Diagnostic advisors are dependent on correct user inputs for functional checks and may not be able to recover from this situation.

Reentry of Fault/Symptom Information After a Functional Check

The results of a functional check can be entered into the diagnostic system either automatically or manually. Automatic feedback, via an aircraft data bus, initializes built-in tests (BITs) and returns symptoms which are directly input to diagnostic activity. Could these methods allow symptoms to be inadvertently alleviated, although not tested, or could newly-observed symptoms be overlooked?

Handling of MIL-STD-1553 Data Bus Outputs

A demonstration of the IMIS portable computer coupled with the presentation and diagnostic modules was accomplished on an F-16 aircraft during 1989. The MIL-STD-1553 data bus was important in downloading system and fault information for use by the diagnostic module. The Fire Control Computer (FCC), via the MIL-STD-1553 data bus, initiated system and fault checks, and received and stored information from BITs. This information was used for both fault verification and initializing diagnostics. Figure 3 illustrates the MIL-STD-1553 data bus with some system connections and shows its usefulness. The block diagram in Figure 4 displays the flow of diagnostics and fault information.

Since the MIL-STD-1553 data bus is so important in fault verifying and initializing the diagnostics process, what outputs can be expected of the portable maintenance aid, and what are the effects of incorrect outputs from the MIL-STD-1553 data bus?

Initialization/Reinitialization of the Diagnostic Session

An important first step for any diagnostic system should be to verify the existence of a fault in the system under test. Current human interface design for the IMIS diagnostic module initializes the sequence based upon the pilot-reported discrepancies contained in the Air Force Technical Order (AFTO) Form 349 (shown in Figure 4 as "debrief"). However, the IMIS diagnostic module does not call for a fault verification procedure before starting the diagnostic routine. Based on the flow of information from Figure 4, what are the potential pitfalls of continuing in this fashion, and what alternatives are available within the diagnostic module that can provide an efficient and effective initialization/reinitialization without fault verification?

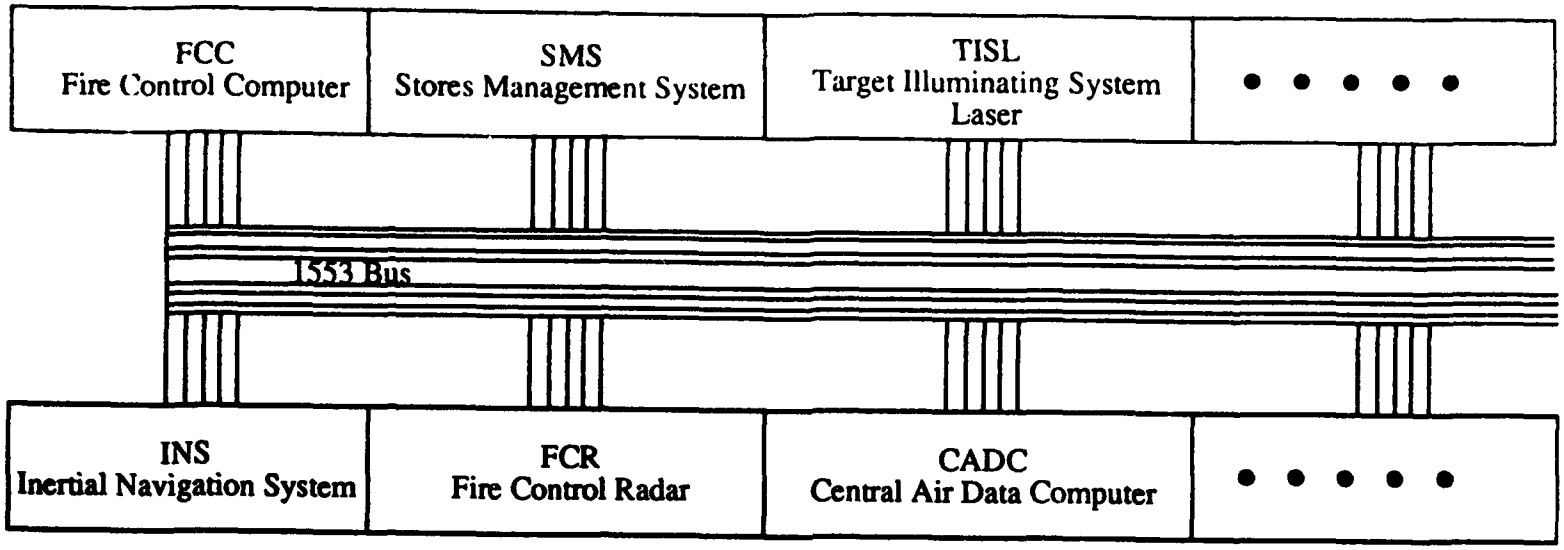

Figure 3. MIL-STD-1553 Data Bus Schematic.

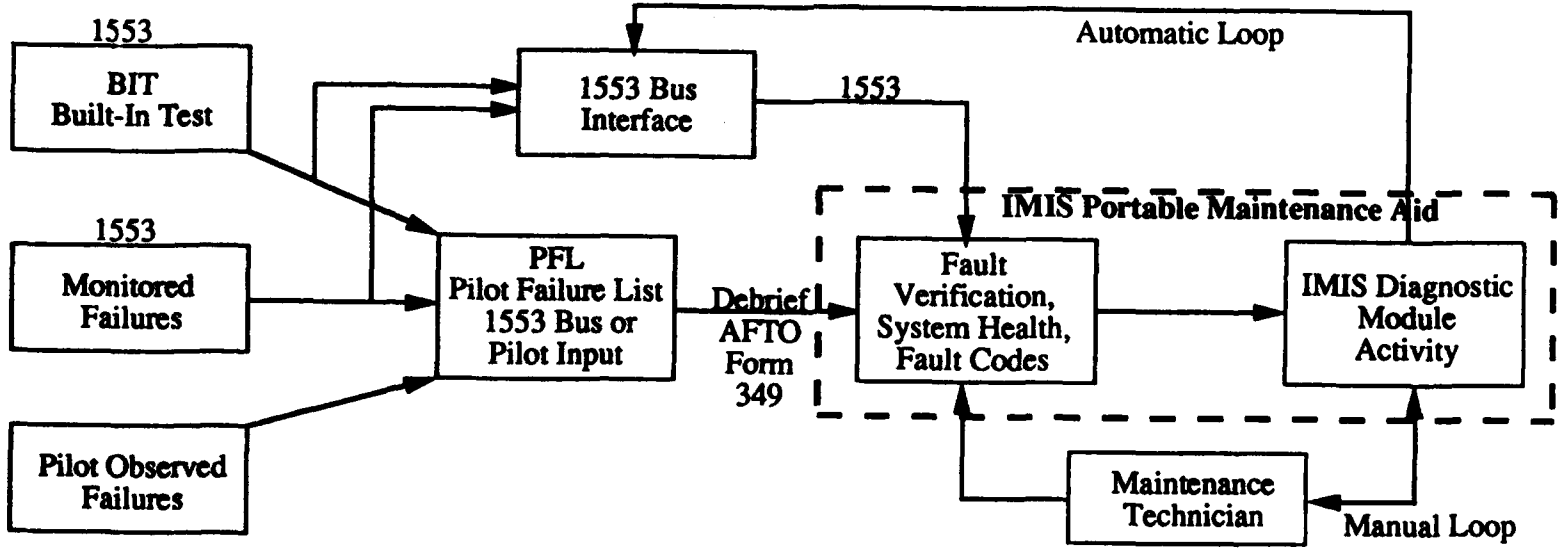

Figure 4. Flow of Diagnostics Information.

Multiple Outcome Tests (MOTs)

As opposed to binary tests which have only two outcomes (pass/fail), MOTs are tests that have three or more possible outcomes.

There are three ways to author and perform MOTs:

1. Exit at first failure. The maintenance technician reports the first failed test outcome only, performs the associated activities, and starts the test over again. This process continues until the MOT is completed with no failures.
2. Complete the MOT and report all failures encountered.
3. Complete the MOT and only report one failure.

A diagnostic tool can be designed to work with any of the three methods or all three. If designed for one of the three, what would be the effect if a test authored for a different method were encountered?

Technical Order Sequencing

While the presence or absence of a correct technical order procedure for performing a required test or maintenance action is a straightforward data base issue, there are two rather more complex technical order sequencing functions which must be treated properly by the user interface if diagnostics are to be completed successfully:

Facilitate Other Maintenance (FOM). In the event that Component A must be removed to gain access to Component B, does the technical order presentation system provide the proper procedures in the proper sequence? Do the rectification and testing sequences reflect reinstallation of all components (A and B) necessary for functional check completion?

Cannibalization. If components are not currently available from supply, cannibalization of another aircraft may be necessary to complete fault rectification or isolation. Does the technical order presentation system provide the capability to sequence cannibalization instructions properly between the donor and receiver aircraft?

III. SYSTEM DESCRIPTION

The scenarios developed for testing the IMIS diagnostic module are general and may be applicable to many diagnostic systems. However, in many cases, the test results are specific to the integrated system developed for the IMIS field demonstration. This system integrates the diagnostic module into a technical data APS. Consequently, a brief description of the structure and operation of the integrated system is warranted before presenting test results.

The basic structure of the tested system is shown in Figure 5. The authoring system is used to create the technical data processed through the diagnostic module and the presentation system and ultimately displayed to the maintenance technician at the user interface. The diagnostic module obtains inputs from the user interface and data from the integrated data base

to develop recommendations for fault isolation/rectification sequencing and provides recommendations for display to the user. The presentation system obtains recommendations from the diagnostic module and technical order data from the integrated data base as well as aircraft status data from the MIL-STD-1553 data bus. The presentation system provides sequenced rules, procedures, graphics, and other information to the maintenance technician and processes feedback from both the aircraft and the technician to define the next display requirement. In addition, the presentation system employs programmable function keys to assist the technician in navigating through the required technical orders and other procedures.

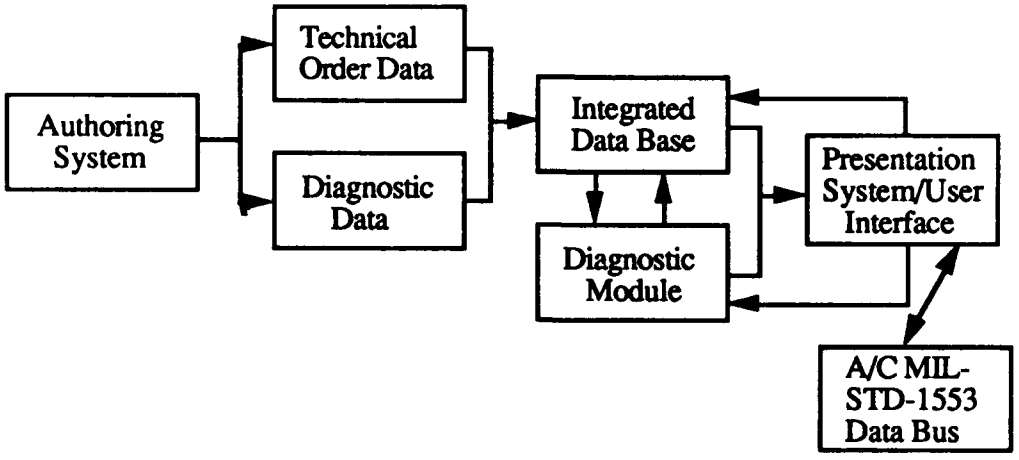

Figure 5. Integrated IMIS Demonstration System.

Key data requirements for the diagnostic module are contained in both the technical order data and the diagnostic data. The technical order data provides test and rectification procedures and times to accomplish these procedures. The diagnostic data base contains a complete list of faults associated with the system under test and fault mapping tables which map faults to symptoms, tests, and rectifications. Data entry for faults includes both the fault MTBF (mandatory) and a fault weight related to a particular symptom (optional).

The structure of the diagnostic module is shown in Figure 6. Fault, symptom, test, and rectification data for the system under test are loaded along with supplemental information regarding criticality (on or off by function), part availability from supply, non-standard aircraft configuration identification, and the symptom(s) which initiated the diagnostic effort. Based upon this information, the module calculates three lists:

1. A "Best Test" list providing a ranked list of available tests useful in isolating the reported fault.
2. A "Best Action" list providing a ranked list of maintenance actions which may be useful in resolving the reported symptom.
3. A "Best Options" list providing a "top five" integrated ranked list of both tests and repairs. The top ranked test or action from this list is presented to the user as the diagnostic module's recommended activity.

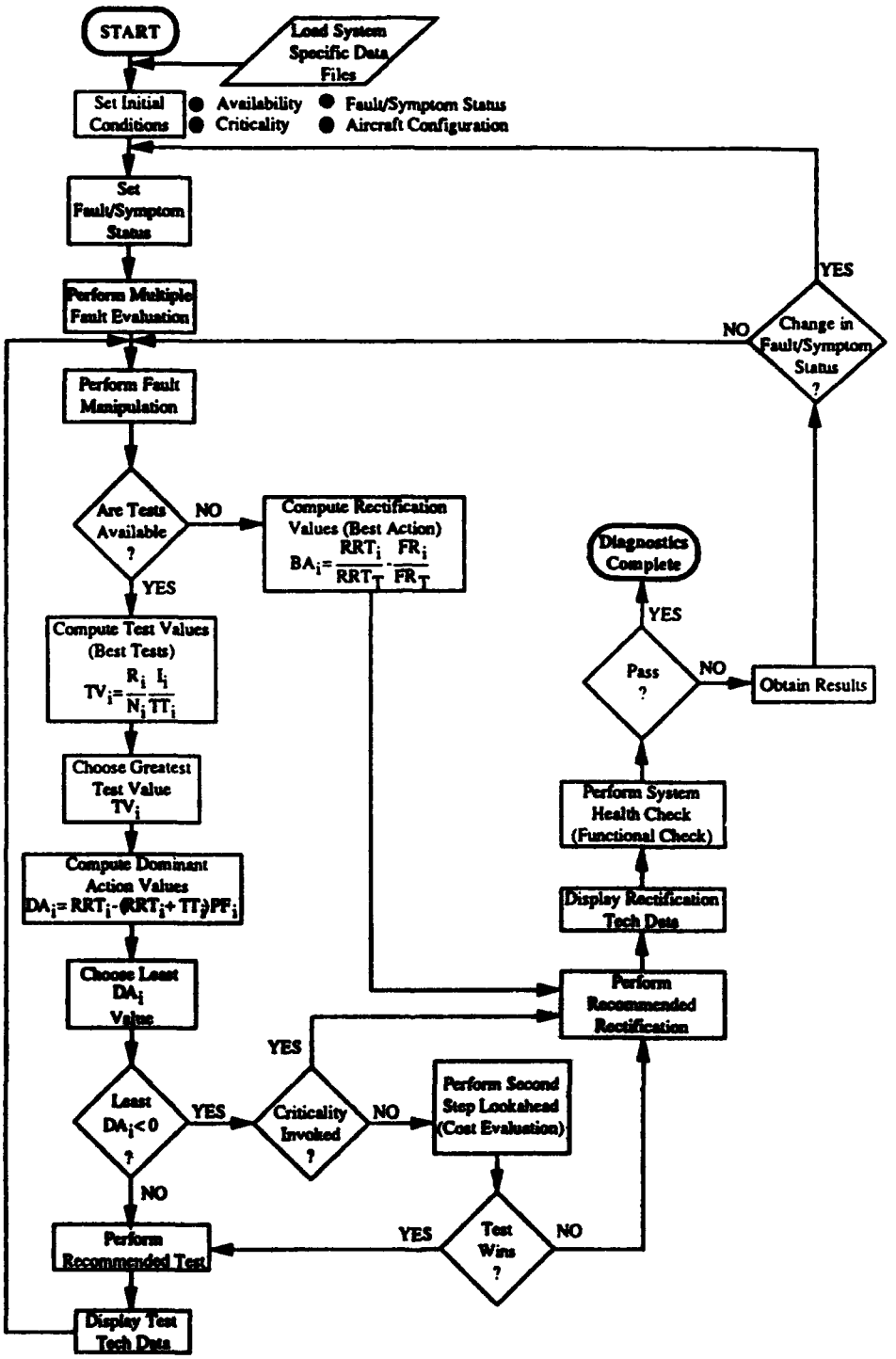

Figure 6. Logic Flow.

The user may select any activity from any of the lists and the presentation system will provide the required technical order instructions for performing the activity. Upon completion of the activity, results are returned to the diagnostic module and the processing continues as necessary until the system is returned to operational status.

IV. IMIS DIAGNOSTIC MODULE TEST RESULTS

Exhaustive test procedures were developed to test the IMIS diagnostic module against each of the scenarios defined in Section II. This section of the paper provides results of the tests performed upon the IMIS diagnostic module. Detailed test procedures and results from each test are provided in the Appendix to this paper. The tests were accomplished on a Sun II workstation using Version 3.3 of the IMIS diagnostic and technical order APS modules. Parameter values were varied, and memory values were observed using the dbx[TM1] facility provided in the Sun version of the UNIX operating system. The results of the testing and analysis of test results provide the basis for the recommendations contained in Section V.

Fault Processing Issues

These tests show that certain fault processing complications can cause problems for the diagnostic module, ranging from inefficiencies to inability to help in fault rectification.

Can Not Duplicate (CND)

The diagnostic module did not easily handle CND problems. There were two CND problems examined during testing. The first CND problem stems from a transient condition which has cleared itself and no longer exists in the system. If fault verification is performed prior to starting the diagnostic module, there will be no degradation of diagnostics. On the other hand, if fault verification is not performed prior to starting the diagnostic module, diagnostics will lead down a series of "passed" tests until only one fault remains, and then a rectification will be performed "successfully." This will lead to an RTOK message at the intermediate level shop.

The second problem examined stems from a situation where there really is a fault in the system, but no test can "see" it. Any test run on the system will pass, so the result will be the same as the unverified CND explained above. The diagnostic module will be of no assistance in this situation, and the fault could only be repaired if, by fortuitous accident, it occurred in the component replaced after the series of tests.

Intermittent Fault

The IMIS diagnostic module was not effective in handling this fault processing problem. If the intermittent fault happens to be present during the diagnostic process, then it could be handled the same as any verified fault. If it disappears, then it looks very much the same as the CND problem.

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[1] dbx[TM] - Sun Work Station (R) Sun Microsystems (Revision A of 17 February 1986)

Tests That Fix

This problem creates a situation that behaves much like a CND problem but occurs after diagnostics have started with a verified fault. It will result in incorrect fault identification and an RTOK.

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Loss of Test Information

Fault handling procedures in the diagnostic module resulted in the loss of test information. In the test, the human operator could see that two simultaneous faults had been isolated to two specific components; yet, the system returned a test recommendation. Fault isolation was ultimately successful, but the most efficient strategy was not recommended (see Test #5 in the Appendix).

Access Groups

The access group algorithms are not incorporated in the current diagnostic module and could not be tested.

"But Not" Data Entry

The IMIS diagnostic module is not designed to take advantage of the additional information provided by the concept of "But Not" data entry. Consequently, faults which might be removed from consideration during initialization must be treated as "possibles" and considered during fault isolation. Although the "But Not" facility is not built into the diagnostic module, the result is inefficient diagnostics (extra steps required) rather than a failure of diagnostics.

Handling of Maintenance Actions

The diagnostic module did not distinguish between a maintenance action--which does not involve a removal or replacement -- and other repair activities. Consequently, as the faults were processed, the system entered a closed loop wherein the same sequence of tests and actions was called repeatedly. Diagnostics were unsuccessful.

Criticality

Selecting criticality, as done in this test, resulted in inefficient diagnostics and delayed the total time to either exculpation of the critical faults, rectification of the critical faults, or rectification of the existing noncritical fault. The criticality function implemented in this version of the IMIS diagnostic module was inefficient.

Data Base Issues

The elements of the data base and the acquisition and use of the data base elements are crucial to proper functioning of the IMIS diagnostic module. This section describes the results of testing that examined the effect of a corrupted data base on the proper operation of the diagnostic module. The error sources examined included human error in entering data, machine (software) error in transferring data from the data entry form to the digital data base, and failure to enter required data in either the diagnostics data base or the technical order data base. Results from testing the data base scenarios are recounted below.

Inaccurate Data

Unseen Fault. A weight value of zero was assigned to a fault and a symptom which implicated that fault was selected as the observed symptom. Such an incorrect entry might result from lack of knowledge about a fault's weight during data entry or the assignment of zero as a default value.

When the value of zero was received by the diagnostic module for a fault/symptom weight, the fault was ignored in all diagnostic displays. Tests and rectifications for the affected fault were not displayed and could not be performed.

Useless Fault. A useless fault was defined in the scenarios section as one which was shown in the data base as implicated by a symptom, when, in fact, the fault had nothing whatever to do with that symptom. The test showed that including such a fault in the data base can reduce diagnostic efficiencies but does not impede the success of the diagnostic effort. If a very low MTBF accompanies the incorrect fault entry in the data base, there is a very real possibility that an RTOK could also result.

Fault/Symptom Probability Errors

1. Incorrect weights/ weights do not sum to 100. The data base was loaded with the weights for the faults in a symptom summing to 73%, and that symptom was selected. Even though weights did not sum to 100, diagnostics continued undisturbed. Correct rectifications were performed based on the probabilities assigned in the table. In conclusion, if weights are in error, the diagnostic module does not have the capability to detect deviations, and diagnostics continue normally with respect to the weights assigned.

2. Incorrect MTBFs (MTBF = infinite). In the data base, the fault MTBFs were assigned as follows: F0=10, F1=9999=largest number that can be entered into the data base for an MTBF value, and F2=10. When this situation was tested, R1 (the corresponding rectification for F1) displayed zero in the options list, but the actual memory value was .000499. Results of this test showed that no information is lost as a result of rounding off numbers in the options list, and all tests and rectifications were displayed in the appropriate ranking with respect to their MTBF values. Diagnostics were completed successfully.

3. Incorrect MTBFs (MTBF = zero). The lowest MTBF value that could be assigned in the data base for an MTBF was zero. A fault, F1, was assigned a zero MTBF value, and diagnostics were performed. The result of a zero MTBF was devastating to the diagnostic module. Processing errors occurred, and all other faults were removed from consideration.

Only tests and rectifications for F1 were considered. Additionally, rectifications associated with F1 had option-list probabilities of 214%. The memory location for F1 contained "NaN" which is an out-of- bounds value that signifies "not a number."

Incomplete Data

Unassigned Fault (Weight/MTBF) Value

1. Weights. In the data base, no weight value was assigned for F1 (the data base form permits a blank entry for input of weight values). The operating system returned a value of 65535, and diagnostics continued by accessing the MTBF as a default value. Unassigned weight values pose no problems with diagnostics if MTBF values are available. The only inefficiency that exists in such a scenario corresponds to the assignment of fault probability values calculated from MTBFs.

2. MTBFs. The data base form requires a positive integer or zero value for an MTBF entry; therefore, undefined entries in the data tables cannot exist and do not pose diagnostic difficulties.

Unmodeled Symptom. A given symptom for the system under test might occur but not be included in the diagnostic data base. Such an event could be the result of oversight when developing the data base or the result of lack of knowledge early in a weapon system life cycle. Whether the symptom was observed by the maintenance technician (manual symptom entry required) or through download from the MIL-STD-1553 bus interface (automatic symptom entry), the result was the same. The observed symptom has to be matched to an existing symptom list in the data base. When the observed symptom could not be found in the symptom list, there was no way to enter the observed symptom or obtain fault information associated with that symptom. If a fault were implicated solely by the unmodeled symptom, the IMIS diagnostic module would not be useful in fault isolation and repair.

Unmodeled Weights/MTBFs for Fault/Symptom Relationship. The data base may contain errors wherein a fault implicated by a symptom may have weight and/or MTBF values missing. The first situation tested considered the absence of both MTBF and weight values for the same fault. When diagnostics were initialized, processing errors occurred and diagnostics were not completed.

The second entries made in the data base involved absence of fault weight and MTBF values in different faults. Since one weight was blank, the diagnostic module reverted to MTBFs for calculation of that weight. The weight value for the other fault was utilized, and its MTBF was not accessed. Diagnostics continued, completing all rectifications.

Accessibility of Maintenance Information

Unmodeled Tests and Rectifications. An observed symptom implicates a fault for which no tests or rectifications are available. Test and rectification mapping were removed from a fault to simulate a fault that has not been modeled for test or rectification relationships. The fault was included in the fault/symptom relationship table, but as it was not modeled to a test or rectification, diagnostics continued rectifying or testing all other faults until the corrupted

fault was the only one left in the plausible set. Diagnostics ended with processing errors because no rectification or test link to technical data was available for the final remaining fault.

Unmodeled or Incorrect Action Times. Unmodeled and incorrect action times were tested by assigning obviously incorrect times to various test and rectification activities in the data base. These included blank entries, zero entries, and very large (99,999) entries. Blank entries in the data base produced the same results as zero entries. The test and action values for the items affected were corrupted, but the tests and actions were available in the diagnostic system, and faults could be successfully isolated and repaired. These entries resulted in successful but inefficient diagnostics.

Entry of very large action times presented no problems to the diagnostic system. Obviously, the tests and rectifications inevitably ended up on the bottom of every ranked list of available activities because of the excessive time required to perform the activity. Assuming the very large value for time was in error, the only impact was inefficient diagnostics.

Useless Tests and Rectifications. This test was performed by remapping faults in the diagnostic data base. A fault was mapped to an incorrect rectification. Each time that fault was isolated, the incorrect rectification was called, and the subsequent functional check failed because the fault was still present. The diagnostic system entered an infinite loop of ineffective repairs and tests. When the same fault was mapped to an incorrect test, the test passed, thus exculpating the fault. When only one fault (not the right one) remained in the plausible set, the recommended rectification did not fix the fault, the functional check failed, and an infinite loop was entered. The diagnostic module was not successful when facing this sort of data base error.

Unseen Test Faults. This test was performed by implicating a fault not contained in the data base. The fault was spanned by a test which also spanned other faults. When the test failed due to the unmodeled fault, an unsuccessful rectification was performed, the functional check failed, and the diagnostic system entered an infinite loop. The IMIS diagnostic module was ineffective in handling this type of data base problem.

Missing Technical Order (TO) Information. Two types of data base problems were associated with missing technical order information. A call from the diagnostic module to the technical order data base was linked to the wrong technical instruction. In this case, diagnostics could not be performed because there was no way to obtain correct instructions for performing tests or rectifications. The other problem was created by removing the link from the procedure. In this test, a computer core dump occurred because there were no data at the address specified by the diagnostic module. In any case, the diagnostic module could not successfully overcome errors created in the technical order data base.

Human Interface Issues

Incorrect User Input

In order to gain full understanding of the effects of user input errors, erroneous data were entered into the diagnostic module. Several critical user interface errors were identified when the following tests were accomplished.

Criticality. Upon system initialization, criticality was invoked. The diagnostic module recommended a critical test. When the test passed, all critical faults were exculpated and diagnostics ended with "Failed Faults Found." At this point, accrued testing and rectification information could not be utilized for further isolation and repair of noncritical faults. Criticality can be deselected in order to return to normal diagnostics any time before all critical faults are exculpated.

Symptom. To investigate possible symptom user interface errors that can occur, a fault was selected as the true fault, and an incorrect symptom was entered as the observed symptom. Testing showed that symptoms can be changed at any point in the diagnostic process, but when a symptom is eliminated, all its faults are exculpated. When incorrect symptom entries were not found and corrected or when symptoms were removed from consideration too soon, all faults associated with these symptoms were exculpated. They could not be recovered with the backup function.

Incorrect Test Results Entry. Incorrect entry of test results by the technician can be the result of either error or failure to understand the questions posed by the user interface. In any case, an incorrect test result entry can have very different effects upon the diagnostic module, depending upon the type of test being run. When a single incorrect "fail" result was entered for a test (not a functional check), the diagnostic module recovered quickly, and the only degradation was in inefficient diagnostics. When a single incorrect "pass" result from a test was entered, the diagnostic module failed, and successful fault isolation was not possible. Either of the two situations could be corrected by striking the "Back Up" key sufficient times to back up beyond the point where the input error occurred.

When the test for which an incorrect entry was made was a functional check, slightly different results were noted. An incorrect or inadvertent "pass" entry resulted in display of "Failed Faults Found" and the system exited diagnostics. There was no opportunity to correct the entry. The only choice available was to start over. An incorrect or inadvertent "fail" entry had little effect. The diagnostic module eventually recovered. The only existing problem was inefficient diagnostics. However, the incorrect entry could be corrected using the backup capability.

Reentry of Fault/Symptom Information After a Functional Check

Although the capability for the IMIS portable computer to interface with the 1553 bus has yet to be implemented for diagnostic initialization and fault verification, instances can be theorized to depict problems that may occur when the results of a functional check are automatically entered into the diagnostic module.

When automatic reentry of symptoms occurs, the reinitialization of diagnostics may exclude symptoms previously observed that were not included in the functional check. The automatic reentry could also exclude manual symptom entries which, when not discovered by the maintenance technician, would go unnoticed. In either case, rectification of all faults may not be completed.

Futhermore, a corrupted 1553 bus output could be an unrecognizable symptom code or could match an existing symptom code. If the corrupted output resulted in an unrecognizable symptom code, the diagnostic module could not find the implicated fault set. If the corrupted 1553 bus output matched an existing symptom code, the diagnostic module would initiate fault isolation on an incorrect set of faults.

Return of More Than One Outcome From a MOT

The diagnostic module allows only one test outcome entry from a MOT. When an outcome is entered, all faults spanned by the test but not implicated by that outcome are exculpated. The test performed on this function was concerned with the effects on the diagnostic module if a MOT authored for "complete test and enter all outcomes" is encountered. When the test was run, the diagnostic system started recalculation of the plausible set immediately after entry of the first outcome. Faults from subsequent planned outcome entries were exculpated and could not be recovered for fault isolation. Since the functional check could not pass because faults were incorrectly exculpated, the system could not successfully complete fault isolation and repair.

Technical Order Sequencing

SEI attempted technical order sequencing for two very difficult problems: Facilitate Other Maintenance (FOM) and cannibalization. FOM and cannibalization are encountered fairly often during diagnostic sessions. The detailed results of these attempts are shown in the Appendix. The presentation system, which assists the technicians in obtaining correct technical order instructions, was unsuccessful in solving these problems. In both problems, the attempt to obtain needed instructions eventually produced an incorrect "Failed Faults Found" termination of the diagnostic problem before the actual diagnostic problem was more complete.

Errors or Inefficiencies in Normal Diagnostics

Nonfunctional Key Entries. When performing normal diagnostic sequences, several key entries are required to provide the diagnostic module with information about the selections and the outcomes of the actions. The "active" keys are depicted on the user interface. When a "non-active" key was depressed, errors occurred and diagnostics "bombed." Nonfunctional key entries are devastating to diagnostics.

Recalculation of List Options. Best tests, rectifications, and actions are three options used extensively to view and select ranked actions. Each list requires extensive calculations be performed when diagnostics are initialized. In the process of performing validation and verification on large data bases, ranked option lists were used to observe and select actions. This led to the discovery that recalculations and rerankings were performed each time an action list was selected for display. The time required to perform this recalculation was approximately 15 seconds and was inefficient since the calculations and rankings were performed during the initialization of the diagnostic module. This inefficiency may become a major problem when a full data base is installed and several symptoms are observed.

Testing and Result Conclusions

The testing performed on the IMIS diagnostic module revealed a great capacity to overcome many potential problems that might be encountered in demanding scenarios. There were, however, several scenarios in which the IMIS diagnostic module could not function normally as a diagnostic aid. Most of the scenarios which resulted in failure of the diagnostic module were associated with the creation or use of the diagnostic data base or the technical order data base. The detailed test procedures and results from each test performed are provided in the Appendix; however, some of the most important test results are summarized below:

1. Data base accuracy requirements. Many of the potential errors in the diagnostic data base or the technical order data base can virtually negate the effectiveness of the diagnostic module. It is absolutely essential that these data bases be exhaustively reviewed for accuracy and completeness.

2. Technical order navigation. Both FOM and cannibalization problems resulted in inadvertent termination of the diagnostic process before successful completion. As these problems are frequently encountered during diagnostics processes, a capability to navigate successfully through these types of exercises should be developed.

3. Criticality treatment. The criticality treatment in this version of the diagnostic module is almost wholly adopted from a version of the diagnostic module that was based upon a single fault assumption. That assumption fostered a policy of "find a single action decision" for the criticality problem. Adopting the single fault solution virtually unchanged with the current multiple fault processing capability has resulted in inefficiencies that must be corrected.

4. "But Not" data entry. Many efficiencies can be gained by adopting a "but not" data entry and processing capability. The diagnostic module cannot take advantage of these efficiencies. This shortfall occurs in initializing the diagnostic process, reinitializing after a functional check, and entering the results of a MOT.

V. RECOMMENDATIONS

Fault Processing Issues

Can Not Duplicate (CND)

The diagnostic module must employ a requirement that fault verification be completed prior to initializing for fault isolation. A strategy should be developed to allow the diagnostic module to account for and act upon the CND problem.

The strategy proposed will take advantage of the data collected by the diagnostic module during a diagnostic session, the data stored in the CAMS, and off-line processing performed at the IMIS workstation. An outline of the proposed strategy follows.

1. Initial CND occurrence in a subsystem:
   Accept this CND as a transient problem and enter CND on AFTO Form 349.

2. Second CND occurrence in the subsystem:
   a. Search for and perform any tests which are not included in the fault verification process, but span faults implicated by the reported symptom.
   b. If no tests are available that meet criteria in a., perform action at the top of the "Best Action" list.
   c. If tests are available that meet criteria of a. and all pass, then perform action at the top of the "Best Action" list.
   d. If tests are selected that meet criteria of a. and fail, then complete diagnostics normally.

3. Third and subsequent CND occurrence:
   Perform second and subsequent recommended action on the "Best Action" list.

Intermittent

Diagnosing intermittent faults is similar to diagnosing CND faults. The strategy developed for the CND problem will probably handle most intermittent faults. Those not caught by the CND strategy will be corrected by their fortuitous exposure during testing. No action to address this problem by itself is recommended.

Tests That Fix

These will be relatively rare, and they result in successful system rectification. The impact is a slight increase in the RTOK rate as shown in Test 4, the Appendix. Action on this problem should be deferred until later development of IMIS diagnostics.

Loss of Test Information

This problem occurs only in spanned faults from a failed test; therefore, the fault will be isolated eventually. The impact is inefficient diagnostics rather than failed diagnostics. It is recommended that a strategy to overcome this effect of the multiple fault handling strategy be developed.

Access Groups

When an access group strategy is employed, the time invested in gaining access to a test point is not wholly a penalty against the test being evaluated if, by gaining access, other useful test points are also revealed. The Best Test algorithm in Version 1.0 of the IMIS diagnostic module was modified to take advantage of this strategy. The diagnostic module submitted for validation and verification did not make use of this modification.

"But Not" Data Entry and Return of More Than One Outcome from a MOT

The "But Not" data entry can be beneficial in rapidly reducing the set of faults to be isolated. However, the usefulness of this technique depends upon the assumptions and requirements of the test procedures. Tests can be authored in at least three methods:

1. Exit at first failure. The test outcome implicates a specific set of faults but does not exonerate faults in other possible outcomes. Tests are authored in this manner if later outcomes depend upon successful results from earlier outcomes.
2. Complete test and enter a single result. Test outcomes are interdependent, and the single result chosen will implicate an appropriate set of faults; other fault sets are exonerated.
3. Complete test and enter all observed failures. Each step of the test presents an independent result (no future steps in the test depend upon a successful outcome from an earlier step); faults spanned by the nonobserved outcomes are exonerated.

Tests authored in accordance with method 3 can make maximum use of "But Not" data entry. However, the current diagnostic module was designed and coded in accordance with method 2.

We recommend the diagnostic module and the appropriate data tables (or TO data) be redesigned to take maximum advantage of a given test procedure. Pending such a redesign, the current diagnostic module code should be modified so that nonentered symptoms or nonentered test results do not exculpate faults inadvertently.

Handling of Maintenance Actions

The diagnostic module treats maintenance actions (actions such as calibrate, adjust, align, etc.) the same as any other rectification. The result is a failure of diagnostics. This problem can be readily overcome by simply questioning the user as to the success of the maintenance action. A "not able to complete" result will immediately implicate some other fault and make the need for a functional check unnecessary.

Criticality

The diagnostic module should be changed so the technician can continue diagnostics and repair after the critical functions have been exonerated. The basic algorithms around which the criticality function was built were modeled for a single fault assumption. The criticality function in the diagnostic module should be redesigned to overcome the identified shortcomings.

Data Base Issues

Inaccurate/Incomplete Data

The consequences of inaccurate data ranged from inefficient diagnostic sequences to total inability to complete diagnostics and occasionally to total system lockup. The following are recommended:

1. Allow for MTBF values greater than 99,999 hours in the data base authoring form.
2. Include editing checks in the data base to prevent errors such as

    a. faults with no rectifications,
    b. symptoms with no faults,
    c. blank MTBFs and weights,
    d. zero MTBFs and weights,
    e. sum of weights not equal to 100, and
    f. test and rectification times equal to zero or blank.

3. Perform verification of the fault-symptom-test-rectification relationships in the diagnostic model data base to ensure that the system under test has been modeled correctly
4. Recode the diagnostic module software so that a missing weight in an implicated fault causes all processing to revert to the use of MTBF.
5. Ensure that the block diagrams accurately depict the fault connectivity and, as closely as possible, actual system or functional layout during verification of the diagnostic data base for a specific system.

Human Interface Issues

Symptom Entry/Change

Once the diagnostic module starts fault processing, deletion of a symptom exculpates all faults implicated by that symptom. The only recovery method available at this time is to back up several steps to an activity prior to the error and repeat all activities which have occurred since the error. The diagnostic module should have a facility to recover easily from an accidental symptom deletion. This recommendation entails developing a procedure to go back several steps with a single keystroke or a short keystroke sequence. The system should recalculate the current situation based upon all actions taken before the error occurred.

Test/Functional Check Results

The diagnostic module should be given a facility to easily correct any test or functional check result which has been entered incorrectly. The only recovery method available at this time is to back up several steps to an activity prior to the error and repeat all activities which have occurred since the error. The recovery process should allow for a single keystroke or a short keystroke sequence to return to the place where the error occurred and recalculate the current position based on all actions after the error.

MIL-STD-1553 Data Bus Interfacing

Although automatic reentry of fault/symptom information from the MIL-STD-1553 data bus has not been implemented in the IMIS diagnostic module, two problem areas must be addressed for correct operation:

1. A fault/symptom verification routine must be implemented to confirm the initial set of symptoms from the AFTO Form 349. This can be accomplished by utilizing symptoms returned from operations (OPS) checks and BITs.
2. Symptoms entered from BITs on the MIL-STD-1553 data bus should automatically update BIT-observed symptoms during a functional check. Human-observed symptoms should only be updated manually.

Technical Order Sequencing

Tests showed that the diagnostic module becomes totally confused when one attempts to obtain technical order data for FOMs or cannibalization routines through the Table of Contents options. The diagnostic module should be redesigned to accommodate the technical order "calls/options" required to perform these actions.

ACRONYMS

AFTO	-	Air Force Technical Order
AFTOMS	-	Air Force Technical Order Management System
APS	-	Authoring and Presentation System
BIT	-	Built-In Test
CAMS	-	Core Automated Maintenance System
CND	-	Can Not Duplicate
F(N)	-	Fault (Number for fault identification)
FCC	-	Fire Control Computer
FOM	-	Facilitate Other Maintenance
IMIS	-	Integrated Maintenance Information System
MOT	-	Multiple Outcome Test
MTBF	-	Mean Time Between Failure
O(N)	-	Outcome (Number)
OPS	-	Operations
PCMAS	-	Portable Computer-Based Maintenance Aiding System
R(N)	-	Rectification (Number)
R & R	-	Remove and Replace
RT	-	Receiver/Transmitter
RTOK	-	Retest OK
REMIS	-	Reliability and Maintainability Information System
S(N)	-	Symptom (Number)
T(N)	-	Test (Number)
TO	-	Technical Order
V & V	-	Validation and Verification

GLOSSARY

Action. A diagnostic or corrective procedure performed by a maintenance technician.

Availability. A component's obtainability for use in the diagnostics process.

Best Action. A diagnostic software equation which chooses the optimum action from among available rectification actions.

Best Test. A diagnostic software procedure which chooses the optimum test from among those available at any point in the diagnostic sequence.

Component. The lowest physical level of indenture on which a maintenance technician at a given level of maintenance (Organizational (O), Intermediate (I), or Depot (D)) will normally work. For example, an organizational level maintenance technician would consider a Line Replaceable Unit (LRU) as a component; whereas an intermediate level technician would consider the LRU an end item and the Shop Replaceable Unit (SRU) a component.

Criticality. A measure of need for a particular system capability. For example, a fault in an air-to-ground function might not be critical for an air defense sortie; whereas, a fault in an air-to-air function would be critical for the same sortie requirement.

Dominant Action. A rectification action whose likelihood of success is so great that it is recommended prior to available tests that would further reduce the plausible set.

Exculpated Fault. A potential fault that has been eliminated from the set of possible faults causing the problem.

Fault. That which causes a piece of equipment to malfunction in some fashion. A fault is the manifestation, through either inference or direct observation, of a failure within a system.

Functional Check. A test performed to ensure that a rectification action has been successful in restoring a system to operational status.

Mean Time Between Failure (MTBF). The unit of reliability used in this program as a predictor of fault likelihood. Its inverse is the failure rate.

Multiple Faults. An event where two or more faults (failed components) occur simultaneously.

Multiple Outcome Test (MOT). A test procedure which does not have a binary pass/fail result. The procedure may have any number of outcomes; however, each is unique and distinguishable from all other outcomes.

Operational (OPS) Check. Frequently used interchangeably with functional check. In this document, it is a test of limited span that ensures that a repair action has been successful in removing a specific, isolated fault.

Parent Rectification. A rectification that includes or contains other lower level rectifications. For example, replacing an initial navigation platform would include an "alignment."

Plausible Set. The set of possible faults which could logically be expected to have led to an observed or indicated faulty condition. The elements in this set of faults contain single faults or combinations of faults that are not redundant.

Rectification. The repair of a fault or set of faults which alleviates a symptom or set of symptoms.

Repair Time. The time required to complete system repair after a fault is isolated. (It may include access times if that time has not already been expended earlier in the process.) It includes the time required to reinstall original components removed unnecessarily as part of diagnostics, secure and close all access panels in the aircraft, and perform the final functional check.

Symptom. An observable indication that a malfunction exists within a piece of equipment (e.g., "Receiver, no audio, or MFL37").

Test. A prescribed sequence of actions that implicates or exonerates a set of faults.

Test Time. *The time required to perform* a test. It includes access time, time to gather necessary test equipment and tools, time to conduct the test procedures, and time needed to record/interpret test results.

APPENDIX:

IMIS DIAGNOSTIC MODULE V&V TEST SHEETS

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 1
2. Test Scenario: Can Not Duplicate (CND)
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, but the symptom cannot be duplicated during the fault verification process due to the CND problem. F2 was designated as the true system fault. Diagnostics are attempted by simply initiating the diagnostic sequence with S0.
5. Steps:

Action	Recommendation	Comment
Case 1. Fault verification is performed prior to initialization.		
Functional check (pass)		No faults found.
Case 2. Fault verification is not performed prior to initialization, diagnostics initialized on pilot reported symptoms.		
a. Initialize w/S0&S1	T7	
b. T7 (pass)	R0	T7 passes as a result of the CND.
c. R0	Functional check	
d. Functional check (pass)	Failed faults found	R0 incorrectly identified as having "fixed" the problem.

6. Test Result: The IMIS diagnostic module cannot handle the CND problem gracefully. Although the apparent problem appeared to have been repaired, in fact, whatever was causing the CND problem is still in the system unless it was fortuitously corrected by the action to repair R0.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 2
2. Test Scenario: Intermittent
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were reported on the AFTO Form 349, F0 is designated as the intermittent fault, and F4 is present as a normal fault. F0 is present during fault verification, but comes and goes randomly during fault isolation tests.

5. Steps:

Action	Recommendation	Comment
a. Initiate w/S0 & S1	T2	T2 was not the diagnostic module's recommended action but was chosen to demonstrate the occurrence of an intermittent fault.
b. T2 (fail)	T0	F0 and F3 implicated. F0 active during this test.
c. T0 (pass)	R2	F0 disappears randomly during this test; therefore, F3 is implicated.
d. R2	Functional check	
e. Functional check (fail)	T7	This check fails; however, only S1 returns from this check. F0,F1,F2 are exculpated.
f. T7 (pass)	R4	F1,F2,F3, all OK. F4 sole remaining fault.

g. R4	Functional check	
h. Functional check		
1. Pass	Failed faults found	If F0 remains dormant, this will be the result. F2 and F4 identified as having caused the problem. F2 identification incorrect. F0 problem still not identified.
2. Fail (S0 returned)	Failed faults not found	All faults associated with S0 have been exculpated and diagnostics end without the rectification of F0.

6. Test Result: The IMIS diagnostic module cannot handle the "intermittent" problem gracefully. Although the apparent problem sometimes appears to have been repaired, in fact, the intermittent problem is still in the system at F0.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 3
2. Test Scenario: Intermittent
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, F0 is the intermittent fault which has resulted in the presence of S0. F0 is present during fault verification, but comes and goes randomly during fault isolation tests.

5. Steps:

Action	Recommendation	Comment
a. Initiate w/S0	T5	
b. T5 (pass)	T4	F2 OK
c. T4 (pass)	R1	F0 went away during testing; so T4 passes, F0 exculpated, F1 sole remaining member of the Plausible Set.
d. R1	Functional check	
e. Functional check (pass)	Failed faults found	This test passes because F0 is still dormant, R1 incorrectly identified as having "fixed" the problem.

6. Test Result: The IMIS diagnostic module cannot handle the "intermittent" problem gracefully. Although the apparent problem appeared to have been repaired, in fact, whatever was causing the intermittent problem is still in the system unless it was fortuitously captured by the action to repair R1.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 4
2. Test Scenario: Tests That Fix
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and F0 was designated as the true system fault. T4 that spans F0 will be considered to remove the fault.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	T4	T4 was designated as a test that fixes.
b. T4 (passes and fixes F0)	R2	F0 is fixed by performing T4, but diagnostics continue choosing the next highest ranked action R2.
c. R2	Functional check	
d. Functional check (pass)	Failed faults found	Diagnostics end reporting that R2 fixed the fault when T4 fixed the true fault F0.

6. Test Result: The IMIS diagnostic module does not recognize that tests can fix faults. The problem appeared to have been repaired by the performance of R2, but T4 fixed the true fault, F0. R2 is also an unnecessary action considering that F0 was fixed by the performance of T4.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 5
2. Test Scenario: Loss of Test Information
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were reported on the AFTO Form 349 while F2 and F3 were designated as the true system faults.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0 &S1	T2	T2 is not the diagnostic module's recommended action, but was chosen to demonstrate loss of test information.
b. T2 (fail)	T0	T2 fails implicating F0 and/or F3.
c. T0 (pass)	R2	T0 passes exculpating F0 and F1. At this point F3 and F2 are known faults and both should be rectified.
d. R2	Functional check	
e. Functional check (fail)	T7	
f. T7 (Outcome 1.3 observed)	R3	T7 splits F3 from F4, but is a useless test because F3 is a known fault from previous test results.
g. R3	Functional check	

h. Functional check (pass)	Failed faults found	Loss of test information resulted in the performance of T7 (useless test) and inefficient diagnostics.

6. Test Result: The IMIS Diagnostic Module can lose test information during diagnostic iterations. Information gained from the performance of T2 and T0 isolated F3, but diagnostics continued to attempt fault isolation by splitting faults F3 and F4 with T7.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 6
2. Test Scenario: "But Not " Data Entry
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, but not S1; and F1 was designated as the true system fault. The occurrence of one symptom but not another symptom should result in the exculpation of faults that are dependent on the occurrence of both symptoms.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	R2	F0, F1, and F2 were selected by the diagnostic module as plausible faults. F2 should not be a plausible fault because it is dependent on the occurrence of both S0 & S1.
b. R2	Functional check	
c. Functional check (fail)	R1	
d. R1	Functional check	
e. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module presently does not handle "But Not" data entries, and as a result, completes diagnostic sessions inefficiently by including faults that are dependent on the occurrence of symptoms that are not observed.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 7
2. Test Scenario: Handling of Maintenance Actions
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and F1 was designated as the true system fault and R1 a maintenance action. A maintenance action may be recommended by the diagnostic module, but while performing this action, the maintenance technician discovers that it cannot be completed and wishes to continue diagnostics.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	T7	
b. T7 (Outcome 1.1 observed)	R1	F1 is isolated.
c. R1	Functional check	R1, a maintenance action, cannot be performed successfully, thus implicating the parent rectification, R5.
d. Functional check (fail)	R0	The fail on the functional check is a result of the non-performance of R1. Diagnostics can be completed with R5, but the diagnostic module assumes that R1 has been performed successfully and F1 has been repaired.
e. R0	Functional check	
f. Functional check (fail)	T7	
g. T7	Repeat of steps a. - f.	

6. Test Result: The IMIS diagnostic module does not recognize that R1 could not be performed. It continues diagnostics as if R1 had been completed and assumes that the fault lies elsewhere in the system. Although R5 is a viable rectification, it is never recommended.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 8
2. Test Scenario: Criticality
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S1 was reported on the AFTO Form 349, F3 was designated as critical and F4 as the true system fault. Designating faults as critical for the next sortie causes the diagnostic module to attack critical faults first, where performing normal diagnostics may result in a quicker total system rectification time.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S1	R3	The diagnostic module attempts to rectify critical faults first.
b. R3	Functional check	
c. Functional check (fail)	R2	
d. R2	Functional check	
e. Functional check (fail)	R4	
f. R4	Functional check	
g. Functional check (pass)	Failed faults found	If criticality had not been invoked, T7 would have been performed and passed, exculpating F2 and F3, and R4 would have been the next recommended action.

6. Test Result: The IMIS diagnostic module's criticality function can be a useful tool, but the module's performance can be hindered if the true fault does not reside in a mission critical component.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 9
2. Test Scenario: Unseen Fault
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and a fault weight of 0 was assigned to F1 (the true fault). Initial data collection and entry may result in a fault/symptom weight assignment of 0 as a default value if no weight has been given.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0 and an F1 weight value of 0.	R2	F1 was displayed in the fault/symptom mapping table, but tests and rectifications to isolate and repair F1 were not displayed in the ranking lists.
b. R2	Functional check	
c. Functional check (fail)	R0	
d. R0	Functional check	
e. Functional check (fail)	R2	
f. R2	Repeat of steps b.-f.	

6. Test Result: The IMIS diagnostic module recognizes a fault/symptom weight value of zero, but considers the combination an infeasible alternative for isolation and repair.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 10
2. Test Scenario: Useless Fault
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0.25	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.25	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.25	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.25	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S1 was reported on the AFTO Form 349, and F0 was incorrectly modeled in the Table Maker as an intersecting fault. F3 was designated as the true system fault. Incorrect modeling of fault/symptom relationships may result in the inclusion of faults in the diagnostic process which are unrelated to the observed symptom.

5. Steps:

Action	Recommendation	Comment
a. Initialized w/S1	T4	T4 was not the diagnostic module's recommended action but was chosen to demonstrate a useless fault.
b. T4 (pass)	R5	
c. R5	Functional check	
d. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module does not recognize an incorrectly modeled fault/symptom relationship and performs diagnostics with the given incorrect information resulting in an increased time to repair the aircraft.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 11
2. Test Scenario: Incorrect Weights/Weights Do Not Sum to 100
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.24	0	0	0	0	0	1	N	1.2			1			1
F3	0	0	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.49	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S1 was reported on the AFTO Form 349 with F2 as the true system fault. Fault/symptom probability errors occur when faults are implicated by a symptom and included in the fault/symptom supporting data base, but carry incorrect weight values or the weights do not sum to 100.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S1	R4	
b. R4	Functional check	
c. Functional check (fail)	R2	
d. R2	Functional check	
e. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module does not recognize incorrect weight values or weights that do not sum to 100, and diagnostics continue normally with respect to the weights assigned.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 12
2. Test Scenario: Incorrect MTBFs (MTBF = infinity)
3. Test Model:

								MOT									
	S0 (MTBF)	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	10	1	1	1	0	1	0	F	0	1					
F1	9999	1	0	0	0	0	0	U	1.1		1				1
F2	10	0	0	0	0	0	1	N	1.2			1			1
		0	1	1	1	0	0	C	1.3				1		1
		0	1	0	0	0	0	K	0					1	
TIME (MIN)		10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and F1 was designated as the true fault. The largest value that could be input for an MTBF was 9999. If an MTBF value is very high, is information lost during diagnostic calculation for fault/symptom weights?

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0		R1 in the options list displayed 0 (rounded), but the actual value observed in dbx™ was .000499.

6. Test Result: The IMIS diagnostic module lost no information as a result of rounding off numbers for the option-list display, and all tests and rectifications were displayed in the appropriate ranking with respect to their MTBF values.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 13
2. Test Scenario: Incorrect MTBFs (MTBF = zero)
3. Test Model:

		MOT													
	S0 (MTBF)	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	10	1	1	1	0	1	0	F	0	1					
F1	0	1	0	0	0	0	0	U	1.1		1				1
F2	10	0	0	0	0	0	1	N	1.2			1			1
		0	1	1	1	0	0	C	1.3				1		1
		0	1	0	0	0	0	K	0					1	
TIME (MIN)		10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and F0 was designated as the true fault. Fault MTBF values are accessed in the event that fault weights are not available. During data entry an MTBF value may not be available and be assigned 0 for a default value.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	R1	Only tests and rectifications for F1 were recommended. R1 and R5 had option-list probabilities of 214%.
b. R1	Functional check	
c. Functional check (fail)	R1	
d. R1	Repeat steps b.-d.	

6. Test Result: The IMIS diagnostic module cannot handle an MTBF of 0. Dbx™ denoted processing errors had occurred, and all other faults, except F1, were alleviated from consideration.

1. Test No. 14
2. Test Scenario: Unassigned Fault Weight/MTBF Values
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1		0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and F1 designated as the true system fault, was not assigned any weight value. During data entry within the data base, some faults may not be assigned a weight value.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	R1	The value of 65535 was received by the diagnostic module and diagnostics continue by accessing MTBF values for F1.
b. R1	Functional check	
c. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module was designed to use fault weights. In the event that fault weights are not available, MTBF values are used as defaults. Diagnostics were completed successfully relative to the MTBF values assigned. The only instance that would create diagnostic difficulties would be if there were missing MTBF values or MTBFs of 0. The Table Maker requires a positive integer or zero value for an MTBF entry; therefore, undefined entries in the data tables cannot exist and do not pose diagnostic difficulties.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 15
2. Test Scenario: Unmodeled Symptom (Manual Entry)
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S2 is observed by a maintenance technician; and manual entry of symptom selection is required to designate symptom occurrence. S2 is not modeled within the diagnostic data base.
5. Steps:

Action	Recommendation	Comment
S2 observed		Data base is not modeled for this symptom and is not displayed to the technician as a choice to initialize diagnostics.

6. Test Result: The IMIS Diagnostic Module cannot be initialized with a symptom that is not modeled in the diagnostic data base.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 16
2. Test Scenario: Unmodeled Symptom (Automatic Entry)
3. Test Model:

									MOT							
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: The AFTO Form 349 in the Authoring and Presentation System was modified to include S0, S1, and an unknown S2. This modification simulates a situation that occurs when the downloading from the 1553 bus exhibits a symptom which has not been included in the diagnostic system's data base.
5. Steps:

Action	Recommendation	Comment
Initialize w/S0, S1 & S2		Upon examination of the symptom availability list, S2 was not available, but S0 and S1 were included as the observed symptoms.

6. Test Result: The IMIS diagnostic module will not initialize a symptom that has not been modeled in the diagnostic data base.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 17
2. Test Scenario: Unmodeled Weights/MTBFs for Fault/Symptom Relationship
3. Test Model:

	S0 (MTBF)	S0 (Weights)	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
									MOT							
F0	10	0.33	1	1	1	0	1	0	F	0	1					
F1	0		1	0	0	0	0	0	U	1.1		1				1
F2	10	0.33	0	0	0	0	0	1	N	1.2			1			1
			0	1	1	1	0	0	C	1.3				1		1
			0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and F1 was assigned a 0 value for its MTBF and an unassigned value for its weight. Faults may be implicated by a symptom, but upon evaluation of weight and MTBF table values, there are missing MTBF and weight values for the same fault.
5. Steps:

Action	Recommendation	Comment
Initialize w/S0	System "bombed"	Processing errors occurred and diagnostics were not completed.

6. Test Result: The IMIS diagnostic module could not be initialized with the occurrence of an unmodeled weight and MTBF for the same fault/symptom relationship.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 18
2. Test Scenario: Unmodeled Weights/MTBFs for Fault/Symptom Relationship
3. Test Model:

	S0 (MTBF)	S0 (Weight)	T0	T1	T2	T3	T4	T5	T6	T7	MOT R0	R1	R2	R3	R4	R5
F0	10		1	1	1	0	1	0	F	0	1					
F1	10	0.33	1	0	0	0	0	0	U	1.1		1				1
F2	0	0.33	0	0	0	0	0	1	N	1.2			1			1
			0	1	1	1	0	0	C	1.3				1		1
			0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349. F0 was assigned a blank weight value and F2 a 0 for the MTBF value. Faults may be implicated by a symptom, but upon evaluation of weight and MTBF table values, there are missing MTBF and weight values for the different faults.

5. Steps:

Action	Recommendation	Comment
Initialize w/S0		The diagnostic module utilized the MTBF value for F0 and the weight value for F2. Diagnostics continued undisturbed.

6. Test Result: The IMIS diagnostic module was able to accomplish diagnostics by normalizing MTBF values for F1 and using the given weight value for F2. This occurrence of missing data provided no problems for the diagnostic module.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 19
2. Test Scenario: Unmodeled Tests and Rectifications
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	0	0	0	0	0	0	U	0						
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and F1 was designated as the true system fault. An observed symptom implicates a fault for which no tests or rectifications are available.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	R2	
b. R2	Functional check	
c. Functional check (fail)	R0	
d. R0	Functional check	
e. Functional check (fail)	R2	
f. R2		System errors occurred and the diagnostic module "locked up."

6. Test Result: The IMIS diagnostic module does not rectify a fault with no tests or rectifications mapped to it. System errors occurred and there was no chance to recover.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 20
2. Test Scenario: Unassigned Values for Test and Rectification Times
3. Test Model:

									MOT								
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10		10	5		5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and T7 (MOT) and R2 were assigned blank action times within the technical order authoring system. F0 was assigned the true system fault.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	R1	T7 and R2 times were corrupted. Both actions were ranked last on the options list and their displayed test values corresponded to their ranking. Test time values displayed in dbx™ were 16,776,440. For example, a ranking of 7 would display an action time of 71. Action times from dbx™.
b. R1	Functional check	
c. Functional check (fail)	R0	
d. R0	Functional check	
e. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module could not handle blank action times, and information from ranked options lists as corrupted. Options with blank action times were ranked last on the options lists, and their action times corresponded to their ranking.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 21
2. Test Scenario: Test and Rectification Times of Zero
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	0	10	10	10	8	0	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were reported on the AFTO Form 349, and T3 and R0 were assigned zero action times within the technical order authoring system. F0 and F3 were designated as true system faults.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	T7	T3 and R0 times were corrupted. Both actions were ranked last on the options list, and their displayed test values corresponded to their ranking. Test time values displayed in dbx™ were 16,776,440. For example,a ranking of 7 would display an action time of 71. Action times from dbx™.
b. T7 (outcome 1.3)	R3	
c. R3	Functional check	
d. Functional check (fail)	R0	S1 alleviated as a result of R3.
e. R0	Functional check	
f. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module could not handle zero action times, and information from ranked options lists were corrupted. Options with zero action times were ranked last on the options lists, and their action times corresponded to their ranking.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 22
2. Test Scenario: Test and Rectification Times of Infinite
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			INF	10	10	10	10	10	10	8	10	INF	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349, and T1 and R1 were assigned infinite (99,999,999 largest entry) action times within the technical order authoring system. F0 was assigned the true system fault.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	R2	T1 and R1 times were not corrupted. Both actions were ranked last on the options list as expected from their action times.
b. R2	Functional check	
c. Functional check (fail)	R0	
d. R0	Functional check	
e. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module did not have problems with infinite action times. Action times were ranked correctly according to their probability of occurrence and assigned action times.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 23
2. Test Scenario: Useless Tests and Rectifications
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1	1				
F1	0.33	0	1	0	0	0	1	0	U	1.1						1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349 and F0 was designated as the true system fault. R1 was incorrectly modeled to fix F0.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	T4	T4 was not the diagnostics recommended action but was chosen to show the results of a useless test.
b. T4 (fail)	R5	
c. R5	Functional check	
d. Functional check (fail)	R1	
e. R1	Functional check	
f. Functional check (fail)	R5	
g. R5	Repeat steps c.-g.	

6. Test Result: The IMIS diagnostic module could not repair a fault that corresponded to a useless rectification or test. The diagnostic module receives incorrect diagnostic information from the tests and rectifications that are incorrectly modeled. There are two outcomes that can transpire as a result of a useless action:

a. The fault is not rectified and diagnostics continue in an infinite loop.
b. The fault is rectified by a parent rectification.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 24
2. Test Scenario: Unseen Test Faults
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	1	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 and S1 were reported on the AFTO Form 349, and F0 and F4 were designated as the true system fault. A data base error has resulted in failure to correctly map F4 to T5.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0 & S1	T5	T5 was not recommended by the diagnostic module but was selected to demonstrate an unseen test fault.
b. T5 (fail)	R2	T5 failed due to F4, but the module incorrectly ascribes the failure to F2 because of the data base error.
c. R2	Functional check	
d. Functional check (fail)	T7	
e. T7 (pass)	R0	
f. R0	Functional check	
g. Functional check (fail)	R4	
h. R4	Functional check	
i. Functional check (pass)	Failed faults found	Diagnostics end.

6. Test Result: The IMIS diagnostic module exhibits some inefficiencies as a result of the data entry, but diagnostics were completed and the correct rectification was completed successfully.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 25
2. Test Scenario: Missing Technical Order (TO) Information
3. Test Model:

											MOT					
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0						
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2						1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptom S0 was reported on the AFTO Form 349. The TO information for R0 was remapped to R1, and the TO call for R2 was alleviated.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	R1	The following rectification choices were not those recommended by the diagnostic module but were selected to demonstrate the diagnostic scenario. R1 displayed the TO information of R0.
b. Back up out of R1	R2	System errors occur and the diagnostic module "bombs."

6. Test Result: If a request for TO information produces the incorrect TO or if TO information is missing, the IMIS diagnostic module does not have the ability to recover. Incorrect TOs display an incorrect maintenance procedure for a given test or rectification. In the event of missing TO information, diagnostics "bomb" and cannot be continued.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 26
2. Test Scenario: Incorrect Criticality Input
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were reported on the AFTO Form 349, and F2 was the designated true system fault. In the event that criticality is incorrectly selected, adverse effects on diagnostics can occur.
5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0 & S1	T1	Critical test
b. T1 (pass)	Failed faults found	Diagnostics end without rectifying F2, the true fault.

6. Test Result: The IMIS diagnostic module ends diagnostics upon exculpation of all critical faults and cannot continue diagnostics if the true system fault is not critical. Diagnostic information learned during the first session cannot be used to reinitialize diagnostics if time remains to rectify the true system fault.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 27
2. Test Scenario: Incorrect Symptom Input
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were observed. Symptom S0 was reported on the AFTO Form 349 and not S1. F0 and F3 were the designated true system faults.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0	T7	
b. T7 (outcome 1.3)		Realization that symptom S1 was not selected during initialization. Upon reselection of S1, S0 was accidentally deselected.
c. Select S1/deselect S0	R3	
d. R3	Functional check	
e. Functional check (pass)	Failed faults found	

6. Test Result: The IMIS diagnostic module will allow symptom entry at any point in diagnostics; but the deselection of a symptom exculpates the faults associated only with that symptom, and the faults cannot be recovered with the backup function or by reselecting that symptom.

1. Test No. 28

2. Test Scenario: Single and Continuous Incorrect Test Result Entries and Continuing Diagnostics without Correct Reentry of Test Outcome

3. Test Model:

									MOT								
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were reported on the AFTO Form 349, and F2 was designated as the true system fault.

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0 & S1	T7	
b. T7 (pass)	R0	Outcome 1.2 was observed but was not entered as a "fail." The incorrect "pass" entry on T7 exculpates F1, F2, and F3.
c. R0	Functional check	
d. Functional check (fail)	R0	
e. R0	Repeat steps b.-e.	F2 is never rectified.

6. Test Result: The IMIS diagnostic module cannot handle incorrect test result entries if the entries are not corrected. If the error is caught by the technician, the backup function can be used to back up and change the incorrect test entry, but if not caught, can be devastating to diagnostic effectiveness. Continuous incorrect test entries were performed with the same testing and produced the same results.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 29
2. Test Scenario: Single and Continuous Incorrect Entry from a Functional Check
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were reported on the AFTO Form 349, and F2 was designated as the true system fault.
5. Steps:

Action	Recommendation	Comment
Case 1 ("Pass" when results report "fail")		
a. Initialize w/S0 & S1	R1	R1 was not the recommended option but was chosen to demonstrate the results of incorrect functional check result entries.
b. R1	Functional check	
c. Functional check (pass)	Failed faults found	The functional check was incorrectly reported as passing because F2 was the true fault and had not been rectified. No available option can change the incorrect entry after diagnostics end.
Case 2 ("Fail" when results report "pass")		
a. Initialize w/S0 & S1	T7	
b. T7 (outcome 1.2)	R2	
c. R2	Functional check	

d. Functional check (fail)	R4	The functional check was incorrectly reported as failing because F2 was the true fault and had been rectified.
e. R4	Functional check	
Single incorrect entry		
f. Functional check (pass)	Failed faults found	
Continuous incorrect entry		
g. Functional check (fail)	R0	
h. R0	Functional check	
i. Functional check (fail)	R2	
j. R2	Functional check	
k. Functional check (fail)	R4	
l. R4	Repeat steps e.-h.	

6. Test Result: The IMIS diagnostic module cannot recover from an incorrect pass on a functional check. A single incorrect functional check fail can be corrected with the backup function, paging through the rectification, and reentering the functional check outcome, or will be corrected when the next functional check is performed. Continuous incorrect functional check "fails" result in an infinite loop, and the diagnostic module is not exited although the true fault is rectified.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 30

2. Test Scenario: Reentry of Fault/Symptom Information After a Functional Check

3. Scenario/Test Result: Although the capability for the IMIS portable computer to interface with the 1553 bus has yet to be implemented for diagnostic initialization and fault verification, instances can be theorized to depict problems that may occur when the results of a functional check are automatically entered into the diagnostic module.

a. When automatic reentry of symptoms occur, the reinitialization of diagnostics may exclude symptoms previously observed that were not included in the functional check. The automatic reentry could also exclude manual symptom entries which, when not discovered by the maintenance technician, will go unnoticed. In either case, rectification of all faults may not be completed.

b. A corrupted symptom code can appear as a wrong symptom or go unnoticed. Symptoms with corrupted symptom codes (that correspond to other real symptom codes) will utilize all real symptom mapping information, and diagnostics will attempt to isolate or repair a fault in the real symptom. Symptoms with corrupted symptom codes (matches are not made to modeled symptom codes) will not be initialized into diagnostics as a result of an unmodeled symptom.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 31
2. Test Scenario: Return of More Than One Outcome from an MOT
3. Test Model:

			MOT													
	S0	S1	T0	T1	T2	T3	T4	T5	T6	T7	R0	R1	R2	R3	R4	R5
F0	0.33	0	1	1	1	0	1	0	F	0	1					
F1	0.33	0	1	0	0	0	0	0	U	1.1		1				1
F2	0.33	0.33	0	0	0	0	0	1	N	1.2			1			1
F3	0	0.33	0	1	1	1	0	0	C	1.3				1		1
F4	0	0.33	0	1	0	0	0	0	K	0					1	
TIME (MIN)			10	10	10	10	10	10	10	8	10	5	5	5	10	10

F-Fault S-Symptom R-Rectification T-Test MOT-Multiple Outcome Test

4. Test Procedure/Scenario: Symptoms S0 and S1 were reported on the AFTO Form 349, and F2 and F3 were designated as the true system faults. MOTs have more than one test outcome. When more than one outcome is observed, does the diagnostic module have the capability to rectify more than one outcome?

5. Steps:

Action	Recommendation	Comment
a. Initialize w/S0 & S1	T7	
b. T7 (outcome 1.2 & 1.3)	R2	Only one outcome can be entered for the MOT. Outcome 1.2 was chosen, and the fault associated with Outcome 1.3 is exculpated.
c. R2	Functional check	
d. Functional check (fail)	R0	
e. R0	Functional check	
f. Functional check (fail)	R4	
g. R4	Repeat steps b.-g.	

6. Test Result: The IMIS diagnostic module does not have the ability to accept more than one outcome from an MOT. Only one outcome can be chosen, and the faults associated with the remaining outcomes are exculpated.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 32
2. Test Scenario: Facilitate Other Maintenance (FOM)
3. Test Model: Testing was performed to investigate the diagnostic module's ability to FOM when a rectification is being performed.
4. Test Procedure/Scenario:

	Selection	Action
a.	N/A	Initialize
b.	Rectification	Perform access step
c.	FOM	Remove
d.	Rectification	Remove
e.	Rectification	Install
f.	FOM	Install

5. Steps:

	Action	Recommendation	Comment
a.	Initialize	Select rectification	
b.	Perform access step	Facilitate other maintenance	A component from another rectification must be removed prior to performing the diagnostic module's recommended action from step a.
c.	Select TOC		TOC deactivated, use backup function instead.
d.	Backup went to FC	Functional check	
e.	Select Back Up option	Failed faults found	Backup passed FC, diagnostics end.

f. Select some rectification	Diagnostics were completed with step e., and selection of some other maintenance action could not be performed.

6. Test Result: The IMIS diagnostic module will not facilitate other maintenance actions. TO procedures must correctly address all maintenance activity associated with the removal and replacement of components; otherwise, the rectification cannot be completed successfully.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 33

2. Test Scenario: Cannibalization

3. Test Procedure/Scenario: A method was investigated to provide the proper TO sequencing for cannibalization of another A/C.

4. Test Procedure/Scenario:

	Selection	Action	Aircraft
a.	N/A	Initialize	
b.	Rectification	Remove	A/C-1
c.	Rectification	Remove	A/C-2
d.	Rectification	Install	A/C-1
e.	Isolation	Functional check (pass)	A/C-1
f.	Rectification	Remove	A/C-1
g.	Rectification	Install	A/C-2
h.	N/A	Functional check (pass)	A/C-2
i.	Rectification	Restore	A/C-1
j.	Rectification	Restore	A/C-2

5. Steps:

	Action	Recommendation	Comment
a.	Initialize	Select rectification	
b.	Perform removal sequence		Remove Part 1 (P1) from A/C-1
c.	Select TOC		TOC deactivated, use Back Up instead.
d.	Back up to top of remove		
e.		Select same rectification	
f.	Perform removal sequence		Remove P1 from A/C-2. There is no facility within the diagnostic module to document rectification procedures are being performed on two A/C.
g.		Continue same rectification	

h.	Perform replacement sequence	Functional check	Replace P1 (from A/C-2) into A/C-1.
i.	Functional check	Failed faults found (pass)	Diagnostics end and the rectification/isolation is complete on A/C-1, but A/C-2 parts are lying all over the ramp.
j.	Select TOC	TOC deactivated	If P1 was for isolation, procedures cannot be accessed to take P1 from A/C-1 and restore A/C-2. Otherwise, if cannibalization was for rectification, same comments as step g.

5. Test Result: The IMIS diagnostic module did not have the facility or the ability to perform cannibalization procedures. In the event that the cannibalization effort was for isolation, diagnostics end without restoring A/C-2. If the effort was for rectification, A/C-2 parts are lying all over the ramp.

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 34

2. Test Scenario: Nonfunctional Key Entries

3. Scenario/Result: When performing normal diagnostic sequences, several key entries are required to provide the diagnostic module with information about the selection and the outcomes of actions. If a nonfunctional key entry is made, processing errors occur and diagnostics "bomb."

IMIS Diagnostic Module V&V Test Sheet

1. Test No. 35

2. Test Scenario: Recalculation of List Options

3. Scenario/Result: Best tests, best rectifications, and best actions are three options that are used extensively to view and select ranked actions. Each list requires an enormous amount of calculation which is performed when diagnostics are initialized. In the process of performing validation and verification on the large data base, ranked options lists were selected to perform actions. This led to the discovery that recalculations and rerankings were performed each time an action list was selected for display. The time required to perform this was approximately 15 seconds and was completely unnecessary since the calculations and rankings were performed during the initialization of the diagnostic module. This inefficiency may become a major problem when a full data base is installed and several symptoms are observed.